1964

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THE REPAIR-REPLACEMENT DECISION

--WHAT IS INVOLVED--

by

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A Thesis submitted to the Faculty of the School of Government, Business and International Affairs of The George Washington University in partial satisfaction of the requirements for the degree of Master of Business Administration

June 5, 1964

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CHAPTER I

INTRODUCTION

> I emphasize the inescapability of the scarcity of resources and the necessity for choice because many people seem to believe that the scarcity of resources and the resulting limits in our Defense budget are really the invention of the Bureau of the Budget, the Comptroller's office, or the Appropriation Committees. They are not. The limitation on our national resources is a fact of life, like the laws of physics or aerodynamics. There are other needs and demands for those resources besides the demands of defense, and of expanding science and technology . . . . Therefore, only a limited amount of resources is available for defense. And it is our responsibility, both yours and mine, military and civilian working together, to get the most out of our limited resources by facing up to the hard choices and helping those who made the decisions to make the right ones.[1]

So said Alain C. Enthoven, Assistant Secretary of Defense, System Analysis, in a speech given at the Naval War College on January 6, 1963. This statement, regardless of one's personal beliefs, presents a concise summary of the managerial climate now prevailing in the Department of Defense. For every existing or proposed plan for the expenditure of funds there are many possible alternative courses of action that can be taken. Today's Defense managers require that each must be considered or reconsidered, as the case may be, to ensure that the present or planned allocation of resources is the most economical matrix

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[1]Alain C. Enthoven, "Choosing Strategies and Selection of Weapon Systems," U.S. Naval Institute Proceedings, January, 1964, p. 152.

possible under present conditions. The term, "economical," as it is used here, does not necessarily mean the expenditure of the fewest investment dollars or even the cheapest way of performing the function. Rather it refers to the most efficient and effective way of achieving the given objective with an acceptable degree of assurance.

Whenever there is a desire to evaluate the economic flux of the available resources, one area that is always scrutinized is that of maintenance. Although this contemplation normally encompasses the entire maintenance effort, both equipment and real property, the scope of this paper does not. This paper has been restricted to equipment maintenance, due to the size and complexity of that endeavor. The failure to restrict further the scope of this paper within the area of equipment maintenance might be validly questioned. However, following the precedent of the writers of the available literature in this field, no further restriction has been made.

The examination of equipment upkeep and repair as an area in which the combination of resources can be improved is, primarily, the result of two factors. First, the function of maintenance consumes a very large portion of the total dollars spent in the Department of Defense; therefore, there is a greater probability of finding an opportunity to improve the economic mix in this area than there is in an area where fewer dollars are spent. Secondly, when this atmosphere of "Let us check our economic pattern" prevails, procurement funds for the routine replacement of equipment are normally more difficult to

justify, are reduced, or are non-existent. In this situation the only way that a service can meet its predetermined requirements of having a given number of specific equipments on hand and available for use is to increase or improve its maintenance effort. The extent to which this is achieved is directly proportionate to the extent that the increased maintenance effort extends the physical life of the items involved.

In short, maintenance can be used as a substitute for procurement; and it should be, so long as this is economical--that is, so long as the current and future operating and maintenance costs of the item being repaired do not exceed the initial investment and future operation and maintenance costs of the replacement item.

The situation described above creates pressures which tend to change operating patterns and organizational structures. When management, with a view toward effecting improvement, wishes to examine or reexamine how well it has been performing in an area or functional field, it must have information fed to it by the organization. When the organization is as diverse and complex as the Department of Defense, management must also be given assurance as to the validity and compatibility of the data it receives. This usually means, "in conformity with Parkinson's Law," the creation of new information and control systems. Then, after the creation of the new systems, the selection of common terminology, the implementation of any improvements deemed desirable, and the setting of common

standards, it is only logical to require a feedback system to ensure continued good performance. At the moment this evolutionary process within the Defense Department is at the stage of activating the "required" new systems. These systems, whose purposes are adequately described by their titles, are the Equipment Readiness Reporting System, the Depot Maintenance Programming System, the Depot Maintenance Production Reporting System, the Maintenance Cost Accounting System, and the Maintenance Management Information System. The actual centralization that will be effected by these systems will in large measure depend upon the capability of men and electronic machines to standardize, to render compatible the data generated, and to use this information for the accomplishment of the organization's objectives.

While this pressure appears to be the dominant one generated by management's increased interest in equipment maintenance, it is not the only one that exists. One Department of Defense study group had this to say:

> Material management. The range of functions embracing acquisition, control, storage, issue, and the disposal of material, including, but not limited to such elements as allowance, cataloguing, distributing, leveling, maintenance, usage, and transportation; the full logistics life cycle of any item, beginning at the design stage and proceeding to consumption or disposal.[1]
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> . . . .

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[1]U.S., Department of Defense, Office of Assistant Secretary of Defense, Installation and Logistics, Responsive Automated Material Management System 1968 (A Plan), Report of Material Management Data System Study Group, November, 1962, p. 17.

In addition, the material manager will:

(1) Concurrently manage both the end item and its repair parts.

(2) Have a closer relation with maintenance, to include the scheduling of repairables.

(3) Have a closer relationship with industry regarding technical data, engineering changes, product improvement, etc.

(4) Have a closer relationship with his customers.

(5) Have full knowledge of, and participate in organizational equipment authorization; and will have knowledge of equipment in-use throughout DoD.

(6) Collect and use item usage data.

(7) Insure homogeneous groupings of items in realistic quantity groupings.

(8) Participate in research and development to satisfy provisioning requirements.

(9) Operate, together with subordinate levels, under one system, using standardized policies and management concepts.[1]

. . . .

Maintenance will be aided through the following: coding of military essentiality, item applicability and relationship to the next higher assembly; comparable data on operating systems will be applied to those in research and development; repairable item stock levels will be tailored more to item characteristics rather than issue rates; performance/failure data will flow through maintenance technical channels for product improvement and interservice, including DSA, maintenance support will be increased.[2]

. . . .

Hi-value Items. A category of repairable items of high unit cost or high investment level which because of their extreme military essentiality require intense management control throughout their useful life. This management will include the maintenance of asset information to reflect quantities in store, in transit, installed, and undergoing repair.[3]

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[1] _Ibid._, p. 11

[2] _Ibid._, p. iv.

[3] _Ibid._, p. 31.

> . . . .
> The identity of high cost replacement and repairable items will be related to program elements/resource categories and inventory reporting must reflect investment in these major areas by program elements/resource categories.[1]

This approach combines centralization with vertical integration and will force the logistic manager's influence upon the operating commander during the latter's allocation of his resources.

In the face of these strong pressures for centralization and increased direction for those above, one might ask why one should be concerned with the establishment of economical repair limits. Would it not be better and easier to wait and let the new systems managers take the lead? While there are several good reasons for not doing so, two are distinguishable as better than the rest.

It is quite commonly accepted that hindsight is far more revealing than foresight. Because of this, it is not surprising to find auditors, both internal and external, and higher levels of management, who perform the review function, using hindsight to criticize the foresight of others. Over the years the Marine Corps has often been taken to task for the methods used in determining when an item should be repaired, overhauled, rebuilt, or disposed of as being uneconomical to repair. Usually these rebuffs of the methods then in vogue are not too violent, for the critic seldom has anything to offer in place of that which he does not like. He frequently lets the whole affair go with

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[1] Ibid., p. iii.

the vague comment that "there must be some better way of doing it." The first reason, then, for attempting to find "the economical repair limit" is that for the immediate future; until the new DoD maintenance systems become operative, the Marine Corps is responsible for the manner in which it accomplishes its work. The task of determining when to stop repairing a piece of equipment is part of that work.

Taking a more positive approach, the finding of this limit is important to the commander because in many ways it dictates how he will allocate his resources, and what he can and cannot do. To replace an item prematurely is to spend money needed to buy other materials. To delay replacement unwisely is to expend dollars for a stream of services that are worth less than was paid for them. Either action robs the commanding officer of badly needed resources.

In view of the importance of this decision and the arbitrary manner in which it is so often made in the Marine Corps, it is believed that much would be accomplished by studying the repair-replacement policies, practices, theories, and criteria that are used by civilian industry, in an effort to determine if, or to what extent they are adaptable to Marine Corps use.

Specifically this paper is concerned with:

(1) What theories are used by civilian industry to determine the philosophy that governs the maximum repairability of equipment items?

(2) What factors are used by civilian industry in expressing these theories?

(3) What formulas are used by civilian industry to determine the interrelationship of these factors?

(4) What elements are used in these formulas?

(5) Are the theories and formulas used by civilian industry applicable to the Marine Corps?

(6) What constitutes a good repair-replacement decision making system?

Three methods of research were utilized to gather the data for the resolution of these questions. First, a search was made for literature in this field. Next, inquiries containing six key questions were sent to a selected list of civilian corporations. The third and final method of research used was the interviewing of personnel who are actively engaged in managing the Marine Corps Depot Maintenance System at the Headquarters Marine Corps level.

In searching for writings in this field, the most difficult problem encountered was that of semantics. Pertinent discussions and comments were found under such titles as: repair policies, replacement practices, capital expenditures, capital investment, investment, or management. Notwithstanding the variety of titles under which they wrote, most of the authors were in agreement that the repair-replacement problem is but one phase of investment policy. What was found that surprised the writer was the lack of published literature that contained originality of thought. This was especially

surprising when one considers the importance of the subject. As Joel Dean has said,

> Capital expenditure decisions form the framework for a company's future development and are a major determination of efficiency and competitive power.[1]

Most of the literature in this field was little more than amplification and adaptation of the techniques developed by a few creative authors.

There were several purposes in sending questionnaires to selected corporations. It was reasoned that the data discovered in the literature should be verified or confirmed by comparison with actual practices currently being followed by American businessmen. Information that would disclose the importance that top management placed on the repair-replacement problem was also desired. Furthermore, it was considered desirable to learn the hierarchical levels and functional areas that were responsible for the making of this decision. In this regard all inquiries were addressed to the president of the corporation; as was expected, the majority of the replies (68%) was signed by corporate department heads or higher. The titles of the respondents also showed the role that the firm's financial managers played in this problem. It is not at all surprising to find that the larger, more complex firms were using the capital budget and financial controls as the vehicle for making repair-replacement decisions.

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[1]Joel Dean, "Measuring the Productivity of Capital," _Harvard Business Review_, January-February, 1954, p. 120.

The purpose of the interviews with the managers of the Marine Corps repair-replacement decision making process was to ensure a sufficient understanding of how the "Corps" performs this task. This knowledge was desired in order to avoid the perpetuation of a common failing of auditors--the proposing of solutions with an air of expertise without knowing or recognizing the problem.

As a result of these interviews it can be said with certainty that the Marine Corps has a system for making the repair-replacement decision. It may be further stated that this system is working quite well. The crises and emergencies that are experienced are more the result of the inability to predict the future than of any inherent failures in the system itself.

A criticism that might be made about the present system is not that it will deter the Marines from maintaining their traditional posture of readiness, but rather that it is based upon empirical inference which "follows the grooves and ruts that custom wears and has no track to follow when the groove disappears."[1] It might also be said that the present system does not give the correct and obvious answer.

> Replacement should be made when the required stream of services will thereby be obtained at a lower total cost, or when the improvement in service will be worth more

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[1]U.S., Industrial College of the Armed Forces, Research and Development, Vol. VIII: The Economics of National Security (Washington, D.C.: Industrial College of the Armed Forces, 1958), p. 9.

than the increase in cost.[1]

It should not be inferred that the managers of this Marine decision making process are not interested in finding the "correct and obvious answer." They are, but they also want to keep faith with the Marine that will use the equipment; and they do not control the entire process. "To be effective the replacement program must be financially supported."[2] It is quite logical, but often overlooked, that if one is to act economically, repairs should not be made for lack of procurement dollars, nor should new procurements be made because of a lack of maintenance dollars. This is what is meant by the statement that the replacement program must be financially supported. Anything less than full support will result in the decision makers trying to ensure, through less economical means, their ability to provide the "troops" with the equipment which it has been determined is required by them.

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[1]A. A. Alchian, Economic Replacement Policy (Santa Monica, California: The Rand Corp., April 12, 1952), p. 1.

[2]U.S., Department of Defense, Motor Vehicle Management Within The Department of Defense, Logistic Systems Study Project Phase II, Transportation, September 14, 1959, p. 15.

CHAPTER II

FACTORS AFFECTING INVESTMENT ANALYSIS

Were it possible to summon from the past a leading business executive of 1850 and send him on a tour of American industry, we may be sure he would greet with astonishment the transformation that has occurred since his day in the act of management. He would find, of course, a tremendous increase in the specialization of managerial functions, particularly in the larger enterprises. He would find in the service of the executive a host of unfamiliar mechanical gadgets--telephones, intercommunication systems, typewriters, dictaphones, mimeographs, and an endless profusion of accounting, recording, computing, and tabulating machines. He would find elaborate almost beyond recognition such management techniques as cost accounting, production control, procurement, scheduling, inventory control, quality control, job classification, sales promotion, market analyses, etc., to name only a few. He would find management well on the road to professionalization, with numerous local and national societies sponsoring a growing body of agreed principles and accepted practices. In these and other respects he would note a century of solid progress.

There is one managerial technique, however, in which our visiting executive would feel very much at home. Indeed, it is probably the only one he could take over without first bringing himself up to date. We refer to the technique of analyzing the replacement of production facilities. While the facilities themselves bear little resemblance to their prototypes of 1850, the intellectual process by which the modern executive arrives at a decision on their replaceability is substantially unchanged. Given the requisite familiarity with present day equipment, our visitor could at once make analyses as good as the general run.

That a technique has been substantially unchanged for a century need not, of course, condemn it. Its persistence may signify the attainment of perfection. In the present instance, however, it is impossible to credit this interpretation. Far from perfection the prevailing techniques of replacement analysis are not even intellectually respectable. They have, indeed, no real

intellectual parentage, but are rather specimens of industrial folklore handed down from one generation of managers to the next. It is precisely because they are folklore that our astral executive would have so little to learn in this branch of business administration.

A good technique for analyzing re-equipment proposals is, of course, only one of the requisites of good equipment policy. It is however, a vital and indispensable element. For if management lacks the means to identify, within reasonable limits, the proper timing of replacement decisions in individual cases, it necessarily lacks the means to maintain the most advantageous mechanization of its facilities as a whole. That American industry is still relying almost exclusively on primitive devices inherited from the past is not merely an incongruity; it is a challenge to bring this retarded sector of the managerial art abreast of the others.[1]

It is a fact that there has been some improvement of American industry's equipment replacement policy since this condemnation was written in 1950. However, as President Charles W. Steward, of the Machine and Allied Products Institute, has more recently said, the investment decisions for replacement or modernization are "the most backward management area today . . . the most backward because it's the most difficult."[2] For the reader who would like to examine the quantitative degree of improvement that has taken place, the writer would suggest that he refer to the MAPI survey of policies and practices for equipment replacement and depreciation,[3] to Olm and Richard's

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[1]Machinery and Allied Products Institution, MAPI Replacement Manual (Chicago: The Lake Side Press, R. R. Donnelly and Sons Co., 1950), Forward.

[2]"How to Find the Moment When Modernization Pays Best," Business Week, September, 1958, p. 100.

[3]Machinery and Allied Products Institution, Equipment Replacement and Depreciation--Policy and Practices . . . A Survey (Washington, D.C.: Machinery and Allied Products Institute, 1956).

study of selected Texas banks,[1] and to Chapter IV of this paper. The improvement that has taken place is largely the result of two men: George Terborgh, Research Director of Machinery and Allied Products Institute; and Joel Dean, Professor of Business Economics at Columbia University's Graduate School of Business, and President of his own consulting firm, Joel Dean Associates.[2]

If, as William J. Kelly has said, "a good technique for analyzing re-equipment proposals is, of course, only one of the requisites of good equipment policy,"[3] what does constitute a good equipment analysis policy? Dean has said that there are ten components to a capital-expenditure management program. He has listed them as follows:

> 1. Creative Search for Profitable Opportunities . . . inadvertent opportunities should be supplemented by an active program of seeking out and investigating such opportunities . . . .
> . . . .
> 2. Long Range Capital Plans . . . it is necessary to have some kind of plan sketched out for the future no matter how tentative . . . .
> . . . .
> 3. Short Range Capital Budget . . . the short run budget has several purposes . . . to force operating management to submit . . . capital proposals early . . . to give . . . indication of the company's aggregate demand for funds . . . to stimulate creative thinking . . . early in the game, so . . . there will be . . . time for analysis . . . .

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[1]Kenneth W. Olm and Sandra Richard, Equipment Replacement Policy Among Selected Texas Banks (Bureau of Business Research, University of Texas, 1960).

[2]"How to Find the Moment When Modernization Pays Best," p. 107.

[3]So said William J. Kelly, a former President of Machinery and Allied Products Institute, in the quotation cited at the beginning of Chapter II. See pages 12 and 13.

. . . .
4. Measure of Project Worth . . . this is the critical component of capital management . . . .

. . . .
5. Screening and Selecting . . . screening standards should be set in the light of the supply of cash availability . . . the cost of money . . . the attractiveness of alternative investment opportunities. . . .

. . . .
6. Control of Authorized Outlays. Controls are needed . . . to assure . . . facility conforms with specification . . . that the outlay does not exceed the amount authorized . . . keep estimates of investment amounts honest . . . .

. . . .
7. Post-Mortems . . . to preserve integrity . . . to provide an experience base . . . a post-completion audit of the earnings performance . . . is needed. . . .

. . . .
8. Retirement and Disposal . . . responsibility for an investment project ceases only when the facilities have been disposed of . . . In a dynamic economy economic life projections are necessarily imprecise . . . . specialized assets may come to have more value to others than to the company . . . .

. . . .
9. Forms and Procedures . . . an effective system of capital-expenditure control must . . . be implemented by specialized forms, written project analysis, and routines of approval . . . .

. . . .
10. Economics of Capital Budgeting. Good estimates of the rate of return on capital-expenditure projects require an understanding of the economic concepts that underlie sound investment decisions, as well as ability in estimating techniques. Such understanding can be achieved only through special training.[1]

George Terborgh, though more restrictive in his approach, said basically the same thing when he set forth the functions of good investment policy. These functions as he described them are:

1. Provide a continuous and systematic review of operations in order to spot investment opportunities.
. . . .

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[1]Joel Dean, "Controlling Profitability," Harvard Business Review, January-February, 1954, pp. 121-123.

> 2. Provide a reliable analytical technique for appraising these opportunities.
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> . . . .
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> 3. Maintain a running inventory of desirable projects ranked in the order of urgency.
>
> . . . .
>
> 4. Provide a post audit of its own analysis.[1]

In the commercial world it is not desired that the equipment replacement decisions be made in isolation or on the sole merit of each individual case. Instead, it is desired that each project, after its individual merit has been approved, compete with all other projects that have met the minimum standards set by the company, for the resources that are available. This attitude is not difficult to comprehend or appreciate if you agree with Peter Drucker as to what is the first duty of a business manager. He has said:

> What is the first duty--and the continuing responsibility--of the business manager? . . . to strive for the best possible economic results from the resources currently employed or available. Everything else managers may be expected to do, or may want to do rests on sound economic performance and profitable results over the next few years.[2]

Referring back to the eighth component of Dean's capital-expenditure management program (page 15), the idea that it is the economic life of an item, not necessarily its physical life, that interests the investment analyst can be observed. Terborgh put his finger on the heart of the problem when he

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[1]George W. Terborgh, Business Investment Policy (Washington, D.C.: MAPI), p. 26.

[2]Peter F. Drucker, "Managing for Business Effectiveness," Harvard Business Review, May-June, 1963, p. 53.

said:

> There is no bell that rings when the economic life of an asset expires, either for a particular function or for good and all, nor are there any physical stigmata to distinguish the dead from the living . . .[1]

What is the economic life of an item? How is it determined? The simplest and most correct, but not the most helpful answer is that the economic life of a piece of equipment is the length of time that its use remains profitable.[2] A more descriptive and academic answer has been given by Richard Vancil, who said:

> . . . the economic life of an asset has been defined as the shortest of its (1) physical life, (2) technological life, or (3) product-market. For most equipment investments, the technological life is the limiting one.[3]

An example that illustrates the difference between the physical life and the technological life of an item has been given by Eugene Grant, when he wrote:

> Engineers often use the phrase "percent condition" when referring to this impairment [deterioration] of serviceability. . . . This so-called engineering concept of depreciation has too often been misused in valuation testimony. . . . statements have been all too common to the effect that because an old property has only 2% impairment of serviceableness, it is 98% as valuable as ever, or--even worse--that it is 98% as valuable as the present cost of replacement with an identical property

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[1]Machinery & Allied Products Institute, A Dynamic Equipment Policy for America (Chicago: MAPI, 1946), p. 11.

[2]Replacement Costs in Industry, Report of the National Council of Applied Economic Research, Ministry of Labor and Employment (New Delhi, India: Government of India, 1960), p. 2.

[3]Richard F. Vancil, Leasing of Industrial Equipment (New York: McGraw-Hill Book Co., Inc., 1963), p. 72.

> regardless of the fact that any appropriate replacement might be a quite different and more economical property.[1]

The Machinery and Allied Products Institute phrases it this way:

> Durable goods require, during their service life, a flow of maintenance expenditures which as a rule rise irregularly with age and use. Most of them suffer a deterioration in the quality of their service as time goes on . . . the quality of their service may decline <u>relative to available alternatives</u> even when it does not deteriorate absolutely.[2]

A typical answer as to how to determine what the economical life of an item is has been given by Russell Read, Planning Director for Westinghouse Electric Corporation, who says there is "probably more soul-searching, and possibly more crystal-ball technique in this area of decision than in any other."[3] The most significant points that can be gleaned from the above discussion are the need to plan ahead, so that the alternative investments (replacements) are given equal and fair opportunity in competing for the available fund resources; and the need to determine the true economical life of the equipment being evaluated. Of the former, Dean says:

> . . . but so long as the company is making adequate profits, the drive to have all capital expenditures selected on the basis of profit maximization is blunted; thus, I am aware that making maximum profit is often not the sole or even the dominant goal in managing capital expenditures.[4]

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[1]Eugene L. Grant and Paul T. Norton, Jr., <u>Depreciation</u> (New York: The Roland Press, 1955), p. 14.

[2]MAPI, <u>Dynamic Equipment Policy for America</u>, p. 8.

[3]Olm and Richard, p. 3.

[4]Dean, "Controlling Profitability," <u>Harvard Business Review</u>, p. 121.

Of the latter, Peter Drucker says:

> . . . every analysis of actual allocation of resources and effort in business that I have ever seen or made showed clearly that the bulk of time, work, attention, and money first goes to "problems" rather than opportunities, and secondly, to areas where even extraordinary successful performance will have minimal impact on results.[1]

The truth of the matter is that there is no easy way to determine the length of the economic life of a piece of equipment. Even the most commonly used methods of statistical determination tend to give something other than the economic life. In both the actuarial method and the turnover method[2] the prediction is based on past retirements. If the items were actually replaced at the end of their economic life, then these methods would show the average economical life of the equipment. If they were retired at the end of their physical life, which is a more likely probability, then they would show the average physical life. If the equipments were replaced somewhere between the end of their economical life and the end of their physical life, their average age is somewhere in the twilight zone.

It is recognized that many factors must be considered in determining the economic life of an item. However, because some of these factors are indivisible or are so interrelated to other factors that must be considered in making any repair, replacement, or acquisition decision, no effort has been made in this paper to list them separately. Rather, a combined

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[1]Drucker, Harvard Business Review, p. 54.

[2]Grant and Norton, p. 44.

listing of the factors that must (according to the writers on this subject) be considered by the businessman when he makes his final decision as to which capital expenditures should be made is presented in Table 1.

It is apparent that many of these factors cannot be quantified, or, if quantifiable, the cost to do so would exceed the value of the knowledge gained from it. Nevertheless, it is the quantitative figure in dollars that businessmen understand the best. Therefore, it is not surprising to find Philip Scheuble, Jr., saying:

> The usual starting point of a replacement analysis is the determination of the annual cost savings or dollar profit improvement afforded by the new equipment, the comparison with the status quo . . . .[1]

Dean also says, "The value of a proposed investment depends upon its future earnings."[2]

A listing of the elements that the various writers recommend for consideration in making an estimate of revenues, costs, and the resulting savings is given in Table 2. As in Table 1, not a single author used or recommended the use of all of the items listed in Table 2; in fact, there was considerable disagreement as to how or whether some of them should be used at all. In examining the rationale of each author's techniques and the reasons they advanced for their choice of elements that should

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[1]Philip A. Scheuble, Jr., "How to Figure Equipment Replacement," Harvard Business Review, September-October, 1955, p. 83.

[2]Dean, "Controlling Profitability," Harvard Business Review, p. 127.

TABLE 1

FACTORS AFFECTING THE CAPITAL INVESTMENT DECISION

Realistic Aspirations of Management (Future Plans)
General Business Outlook
Future Markets
Future Products
Action of Competitors
Priority of Replacement (Urgency of Need)
Sufficiency of Overhaul (in Restoring Effectiveness and Service Life)
Availability of Replacement Equipment
Imminent Improvement in Future Equipment
Service Life (Economic Life)
Alternate Uses
Cost Savings
Volume (Use to be made of the Equipment)
Future Cash Earnings
Time Shape of Future Cash Earnings
Net Savings
Taxes
Future Price Levels (Material and Wages)
The Standards by which the Investment Opportunities are Selected
Risk (Probability that the Estimates and Assumptions Employed in the Decision Making Process Are Correct)

TABLE 2

QUANTIFIABLE FACTORS AND COST ELEMENTS OF THE CAPITAL INVESTMENT DECISION[a]

Operating Costs	Other Costs
Wage Rates	Property Taxes
Direct Labor	Tax Depreciation Rate
Indirect Labor	Income Tax Rate over Life
Fringe Benefits	Insurance Costs
Maintenance	Inventory (Level Changes Required)
Repairs	Safety (Cost of Workmen's Compensation)
Tools	
Tool Repair	
Scrap and Rework	Investment
Inspection Costs	Original Cost
Setup Time	Freight
Down Time	Taxes (Sales, etc.)
Material Handling	Handling Charges
Material Costs	Installation Charges
Supplies	
Power Costs	Estimated Scrap Value (Old and New Item)
Floor Space	
Subcontracting Costs	Revenue
Deterioration	Rate of Output (Old and New Item)
Obsolescences	Remaining Economic Life (Old and New Item)
Time Shape of Operating Costs	Time Shape of Earnings

[a]The actual elements utilized are dependent on the technique or formula employed in making the investment analysis.

be used, an opinion was formed that the selection resulted more from the writer's educational background, experience, personal judgment, and the availability of the data, than from scientific study.

In the preceding paragraphs the factors and elements that are used in making the repair, replacement, or investment decision were discussed as facts that exist. Nothing can be farther from the truth. For reasons that they did not state, the majority of the writers did not discuss the problem of gathering the data. This is comparable to a doctor who prescribes a certain medicine for one of his patients without knowing whether or not it is available in the local pharmacy. While not venturing any principles which govern the record-keeping, Terborgh did say that:

> . . . work of the investment specialist can be greatly facilitated by the keeping of records pertinent to his analysis, such as maintenance expenditures, machine hours worked, down time, spoilage of work, and other items.[1]

The maintenance of current and accurate property records and the keeping of reliable maintenance and cost records are essential to a controlled maintenance program, and are kept by many of the larger and/or more progressive business firms.[2] However, as stated in a research project conducted by the

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[1]Terborgh, p. 22.

[2]Richard J. Hanwell, "Controlling Plant and Equipment Costs," Corporation Treasurer's and Controller's Handbook, ed. Lillian Doris (New York: Prentice-Hall, Inc., 1950), p. 300.

Ministry of Labor and Employment, Government of India,

> the expenditures incurred in repairs and maintenance is an important influencing factor in the replacement of fixed equipment. But firms generally find it difficult to maintain separate accounts of repairs and maintenance for individual items of equipment; at best they keep accounts for groups of assets.[1]

The forces that seem to have the greatest effect on the task of record-keeping, and which seem to create most of the problems in this area, are the cost of record-keeping versus the funds available for this purpose, the validity of the data that has been recorded, and the use made of the information collected. It costs money to maintain records and it is not often that the expense can be justified if their sole use is for investment analysis.[2] This is particularly true if the analysis action occurs irregularly or infrequently. The validity of the data is affected, not only by the accuracy with which it is recorded, but also because history never repeats itself--at least, history never repeats itself to the extent that new assets have exactly the same cost expenditures as the old ones which they replaced. In many organizations it is questionable whether the recording system is kept to record the data or the data recorded to perpetuate the system. The importance of knowing the use to be made of the information collected was stressed by Terborgh, when he said:

> Without a good analytical technique for individual investment projects, no amount of system and organization can produce

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[1] Replacement Costs in Industry, p. 6.

[2] Terborgh, p. 22.

> satisfactory results. Once a good technique is adopted, on the other hand, the creation of an appropriate administrative setup for its application is comparatively simple.[1]

In spite of the cost and difficulties involved, it is desirable to make specific money estimates of the cost and revenue flows that are affected or will be created by the investment decision that is made. When the cost elements are not available from records, or their validity is questionable, an engineering or operation study is normally made. In this respect there is no difference between a good operational study, which consists of the same cost elements for one system (technique or formula), and a good one for another; in fact, the analyst does not need to know at this stage what formula will be used.[2]

Knowing the factors and the cost elements used by modern businessmen in making the investment decision does not necessarily portray the rationale or process actually followed by the decision makers. Vancil has summarized the repair-replacement-investment decision making process as follows:

> In reaching a final decision about a proposed new investment, most businessmen use some variation of a two-step approach.
>
> 1. Reduce as much of the information as possible to quantitative terms and summarize it into one figure which measures in some way the attractiveness of the investment.

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[1] *Ibid.*, p. 6.

[2] *Ibid.*, p. 82. It should be noted that Terborgh does not consider many systems, other than his own, to be good.

> 2. Use personal knowledge and experience to decide whether the risk of investment, and other subjective considerations which are not easily measured are adequately compensated for by the quantitative results measured in step 1.
>
> . . . .
>
> The second step is the more difficult one, of course, and little practical progress has been made in helping the businessmen to exercise their judgment on this phase.[1]

It is the difficulty encountered in trying to accomplish this second step that has motivated the more optimistic writers in this field to review, revise, or invent techniques or formulas that will facilitate the quantifying and interrelating of the data used.

While not claiming that their techniques are scientific in nature, the authors of the literature on investment analysis are trying to use methods whose characteristics resemble those of the scientific method as it was described by Alain Enthoven. Those characteristics are:

> First, . . . the method . . . is an open, explicit, verifiable self-correcting process . . . .
>
> . . . .
>
> Second, . . . [the] method is objective . . . .
>
> . . . .
>
> Third, . . . each hypothesis is tested and verified by methods appropriate to the hypothesis in question . . . historically, <u>et cetera</u> . . . .
>
> . . . .
>
> Fourth, . . . quantitative aspects are treated quantitatively . . . .[2]

And so it must be if there is to be further improvement in this field of decision making.

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[1] Vancil, p. 56.

[2] Enthoven, p. 154.

In the next Chapter the mechanics of the investment techniques most commonly discussed in the literature will be presented.

CHAPTER III

TECHNIQUES OF INVESTMENT ANALYSIS

> This country too has its quota of mechanical zombies. One reason for this condition--though by no means the only one--is a frequent lack of understanding by business management of the principles properly governing the economic life of a productive facility. There are available, of course, a multitude of "replacement formulas," but unfortunately most of them are too complex for the average executive. Even more unfortunately, they yield widely different results when applied to the same set of facts; hence it is often more difficult to decide which formula is correct than to apply the one selected. For these reasons it is not surprising that elaborate mathematical procedures for timing replacement have only a limited currency in American industry. They yield in practice to a simpler application of "business judgment," aided frequently in lieu of a more scientific formula, by some simple rule-of-thumb test that happens to be favored by the executive concerned.[1]

The emphasis of study and improvement in investment analysis has been in the techniques and formulas that have been developed to quantify the results of capital expenditure. However, before coming to the conclusion that this weighty problem has been solved, let us consider what Vancil has to say:

> Any quantitative measure of the attractiveness of an investment project is nothing more than a collection of assumptions and estimates about the future. A good analytical procedure for dealing with these estimates is desirable, nevertheless, in order to summarize the estimates into one or two meaningful figures and to avoid any flaws of logic along the way . . . .[2]

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[1] MAPI, _A Dynamic Equipment Policy for America_, pp. 15-16.

[2] Vancil, pp. 74-75.

However, because there have been improvements in the analytical technique and because it is desirable to have "good techniques," "to summarize," and "to avoid any flaws of logic," it does not follow that the formulas in use today are either logical or good.

Before examining the rationale of the six most commonly described techniques, it will be helpful to review the objectives that Dean and Terborgh have set forth for good investment analysis systems. Dean said that:

> . . . a good yardstick of investment worth should summarize in a single figure all the information that is relevant to the decision whether or not to make the particular investment, and none that is irrelevant. It should be applicable to all types of proposals and should permit appraisal in terms of a single set of standards; also, it should provide an index that is relatively simple to compute; once the basic data on the proposal have been assembled, the operating people should be able to measure the project's worth easily and without any need to explain how they do it. Finally, the yardstick should permit simple adjustment to allow for ranges of uncertainty in the earnings estimates, since one of the facts to be taken into account is man's inability to see very far into the future with any great precision.[1]

The requirements for a good formula, as they have been listed by Terborgh, are as follows:[2]

1. It must solve the right problem.

2. Its assumptions must be clear and explicit.

3. It must project future deterioration and obsolescence.

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[1]Dean, "Controlling Profitability," Harvard Business Review, January-February, 1954, p. 123.

[2]Terborgh, p. 8.

4. It must allow for different service values. The allowance for obsolescence should cover service-value obsolescence as well as cost obsolescence.

5. It must allow for income tax.

6. It must handle both present and future salvage values.

7. It must accommodate future capital additions.

8. It must be adaptable to a wide range of projects.

9. It must provide a consistent ranking procedure.

10. It must be simple to apply.

The six theories that prevail in the literature are:

1. The Intuitive Method.
2. The Strict Pay-Out Requirement Method.
3. The Discount-Cash-Flow Method.
4. The Annual Cost Method.
5. The Present-Worth Method.
6. Formula and Charts by Machinery and Allied Products Institute.

<u>The Intuitive Method</u>

The Intuitive Method, sometimes called the "hunch," the sixth sense, or even judgment, is condemned by all of the writers in the field; and yet it is the oldest and most frequently practiced method. While disappointing, this should not be too surprising, for prior to World War II, the state of our technology was not changing very rapidly. The manager's past experience and the empirical data that had been accumulated

were sufficiently accurate in projecting estimates of future costs to be useful in making capital expenditure decisions. In today's age of dynamic technology this is no longer true; to make matters worse, the simple ratios and other mathematical formulas are now less than adequate to evaluate the numerous and varied alternatives that face the decision maker. So, just when the businessman needed help the most, his traditional formulas failed him and he had to rely, more strongly than before, on "personal judgment." Intuition is not a solution--it is the problem, for, as Business Week has aptly put it, "The trouble with intuition is, capable men don't agree."[1]

The Strict Pay-Out Requirement Method

The Strict Pay-Out Requirement Method is also known as the "short pay-off" and as the "pay-off method." It is the oldest of the formalized methods of ranking investment opportunities.[2] In its simplest form it is the expressed relationship between the required dollar amount of the investment and the estimated initial annual operating advantage from the project. Its formula can be expressed as follows:

$$\text{Pay-Out Period} = \frac{I}{\text{Annual Saving}}$$

The annual advantage is divided into the investment to give the pay-out period. Thus, if the initial advantage is \$3,000 and

[1] "Timing New Equipment for Highest Profit," Business Week, July 30, 1955, p. 84.

[2] Olm and Richard, p. 6.

the investment is $10,000, the pay-off period is 3.33 years.

This method has been criticized by most of the writers, particularly Terborgh, Dean, and Norton. Terborgh has stated:

> The basic idea of the device seems to be to find the period of time it will take to recover the investment in a project from the resultant cash flow available for that purpose, in other words, to find the cash break-even point . . . . It must be obvious, first of all, that the pay-off period so defined is not a gauge of prospective profitability, but rather of the turnover rate or liquidity of the investment . . . . Obviously the mere recovery of an investment to cash yields no return at all. If there is a return, it must be because of additional receipts from commitments over and above this recovery.
>
> . . . .
>
> The popularity of the short pay-off requirement is unfortunate both for industry and the country. For, as currently employed predominantly for periods of three years or less, it is a drag on progress without justification or excuse save the advantage of convenience.[1]

Dean has stated:

> Payout period . . . is a misleading measure of capital productivity.[2]
>
> . . . .
>
> It can be used as a coarse screen to shorten the analysis of the best and worst capital proposals. Payback, however, has basic defects: it overweighs the importance of liquidity, ignores capital wastage and fails to take into account the earnings of the project after the initial outlay has been paid back . . . . Payback, consequently, is neither inclusive enough nor sensitive enough to be used as the company's primary measure of investment worth in most situations.[3]

Norton has stated:

> This method is supposed to have the advantage of simplicity, but it is really not at all simple when full

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[1]Terborgh, pp. 29-30.

[2]Joel Dean, Capital Budgeting (New York: Columbia University Press, 1951), p. 22.

[3]Joel Dean, Control for Capital Expenditures (New York: American Management Association, 1953), p. 5.

> consideration is given to all of the factors that should be considered. I cannot conceive of any situation where some other method would not be better than this method.[1]

The attitude of these writers is neatly summarized by Olm and Richard as follows:

> The strict pay-out . . . derives its importance not from the intrinsic worth but from convenience of application--as evidenced by its widespread use by executives in channeling funds for capital expenditures.[2]

However, it is suggested that businessmen use this method in considering when the invested money would again be available. After all, there is still some truth to the old adage--"One bird in the hand is worth two in the bush." While they did not state this idea in so many words, several writers, who were more operationally oriented, hinted at it.[3]

The Discount-Cash-Flow Method

The Discount-Cash-Flow Method, developed extensively by Joel Dean, has often been referred to as "Dean's Method." In its simplest form it is known as the rate of return of the investment. Its underlying principle is that, if the true rate of return of the investment is the rate which equals the present

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[1]Paul T. Norton, Jr., Some Industrial Practices in Capital Goods, Acquisition, and Replacement, An Evaluation of Analytical Techniques of Engineering Economy, Papers of Engineering Economy Committee (Urbana, Ill.: American Society for Engineering Education, June, 1954), p. 121.

[2]Olm and Richard, p. 8.

[3]Scheuble, Harvard Business Review, p. 85.
Also "Capital Budgeting--How to Use It Constructively," Association of Consulting Management Engineers Reporter, 1958, p. 4.

value of outlay with present value of uniform cash earnings over the life of the project, then the ratio of these flows, when discounted at the true rate of return, is equal to unity.[1] The following equation expresses the method of solution:[2]

$$r = \frac{U}{I} - \frac{U}{I}\left(\frac{1}{1+r}\right)^n$$

where U = uniform cash earning flow,

r = true rate of return on the investment,

I = amount of investment, and

successive values of r are substituted on the right hand side of the equation. The annual earnings are divided by the investment to yield the rate of return.

In this form, as is pointed out by several authors, the equation is the reciprocal of the pay-out formula.

While several writers expressed a liking for the overall approach of this method, Terborgh and the Machinery and Allied Products Institute classified it as a rule of thumb device. They explained that this method gives no clue to the rate of return required and that it states as false profits what may be relief from losses caused by the unnecessary deferment of replacement.[3] Terborgh goes on to say:

Any device or formula for replacement analysis that does

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[1]Olm and Richard, p. 9.

[2]Milton H. Spencer and Louis Siegelman, Management Economics (Homewood, Ill.: Richard D. Irwin, Inc., 1959), p. 389.

[3]MAPI, Replacement Manual, p. 6.

> not explicitly nail down these variables [future developments] by estimation and assumption is a snare and a delusion.[1]

The Annual Cost Method

The Annual Cost Method may be defined as a basis for comparison for non-uniform series of money disbursements when money has a time value.[2] Norton defined the objective of the method as the determination, by means of replacement studies, of the annual cost of owning and using one or more proposed machines and of continuing to own and use a present machine.[3] Of the various methods of making the investment studies, the annual cost of capital recovery with a rate of return seems to be one of the more widely used systems.[4]

In computing annual cost, investment is multiplied by a capital-recovery factor. The formula for the capital-recovery factor (crf) may be stated as follows:

$$\text{crf} = \left[\frac{i\ (1+i)^n}{(1+i)^n - 1}\right]$$

where i = minimum attractive rate of return, and

n = number of years with interest rate, i.

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[1] Ibid., p. 8.

[2] Eugene L. Grant, Principles of Engineering Economy (New York: Columbia University Press, 1951), p. 86.

[3] Norton, p. 122.

[4] Olm and Richard, p. 12.

The following example from Grant's work will illustrate the method more clearly:[1]

Machine A
Investment = $10,000
Annual disbursement in connection with ownership = $2,000
Life of Machine = 10 years
Minimum Attractive Rate of Return = 6%

Capital Recovery at 6% = ($10,000)(0.13587)	=	$1,359
Annual Disbursements	=	2,000
Total Annual Cost	=	$3,359

Machine B
Investment = $7,000
Annual Disbursement = $2,500
Life of Machine = 10 years
Minimum Attractive Rate of Return = 6%

Capital Recovery at 6% = ($7,000)(0.13587)	=	$ 951
Annual Disbursements	=	2,500
Total Annual Cost	=	$3,451

Thus it may be seen that Machine A has the lower annual cost.

Again Terborgh has a comment to make:

> It is not sufficient to use a future life which gives the lowest annual cost of owning and using the proposed machine, because inadequate consideration is given to the fact that year by year in the future the machines that will be available for replacement may be expected to become better and better in comparison to the machines available in previous years.[2]

The Present-Worth Method

The Present-Worth Method takes into consideration that "a present-worth dollar is the value today of a dollar invested at a certain interest rate, a given number of years from today."[3]

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[1]Grant, p. 87

[2]Olm and Richard, p. 13.

[3]Claude S. George, Jr., Management in Industry (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1959), p. 265.

The formula for computing the single-payment present-worth amount may be given as follows:

$$\text{Present-Worth of Money} = \text{Future Money}\left[\frac{1}{(1+i)^n}\right]$$

The present-worth formula is similar to that for the calculation of the discounted-cash-flow method, which has been previously described. The difference seems to lie in the fact that discounted-cash-flow seeks an interest rate which discounts future earnings to a present value equalling project cost, while present-worth seeks a cost comparison, similar to the annual cost method. Thus, present-worth can be considered as a basis for monetary comparison, as distinguished from the discounted-cash-flow method. The present-worth factor for uniform annual series payments may be considered as simply the reciprocal of the capital-recovery factor used in computing the annual-cost method.

> In spite of its discussion in the literature, Norton contends that the present-worth method is seldom used in competitive industry.[1]

MAPI Method

The MAPI Method, developed and refined principally by George Terborgh, is the most recent and perhaps the most encompassing formula that has been devised. Like most procedures for assessing the merits of business investment proposals, the MAPI system is addressed to the two basic questions:

1. What is the current annual (next year) operating

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[1]Norton, p. 123.

advantage from the project and by how much will it improve the operating results of the business?

What is the investment merit of the project (rate of return)?[1]

The approach that, to Terborgh and his assistants, seems to make the most sense

> . . . derives the rate of return by comparing the initial annual operating advantage, after income tax and depreciation, with the initial investment (the initial net investment if there are disposals incident to the project).[2]

The determination of this rate of return is not as simple as it might appear. This approach

> would give the right answer if the correct figures were supplied. . . . It may be possible to make a reasonable estimate of the initial annual operating advantage from a project. It may be possible to estimate satisfactorily the investment required . . . possible to compute the income tax chargeable against the initial advantage and to obtain this advantage after tax. But it is not possible to say what further charges should be made against this after-tax advantage for the initial annual consumption of the project investment. This is the missing link in the calculation.[3]
> . . . .
> This is a real headache; not only is it an unfamiliar magnitude to estimate (new investment, the operating advantage, and capital consumption avoided being by comparison commonplace); it is crucially important. For the result of the calculation is highly sensitive to variance in the figure supplied.[4]

Terborgh and his MAPI colleagues have given continuous and imaginative effort to this task of providing businessmen with a simple and quick method of approximating their projects' first year capital consumption cost. This effort has led to the

[1]Terborgh, p. 81.

[2]*Ibid.*, p. 34.

[3]*Ibid.*, p. 34.

[4]*Ibid.*, p. 64.

creation of a set of standard charts. The charts themselves are produced from an elaborate mixture of: the rate at which the new project's earnings will decline; the service life of the new equipment; its final value for sale, trade-in, or scrap; the corporate tax rate; the company's depreciation system; the ratio of the company's debt to its total investment; the interest rate it pays on borrowed capital; and the after-tax return it gets on equity capital.[1]

The MAPI charts have pre-computed all of these things. They have assumed that a 25% debt ratio, a 3% interest rate, and a 10% after-tax return on capital are about the normal for most companies. There are three charts because MAPI offers the analyst three general patterns in which the earnings of a new machine will decline over the years of its service life. In some cases the annual earnings predicted for the new machines will have declined by one-half by the time they have worked half of their service life; in others, annual earnings will have declined by only one-third when the machine's service life is half over; and in some cases, annual earnings will have shrunk by two-thirds when half the new machine's estimated service life is gone.

The logic upon which the MAPI Method is based is as follows:

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[1] Ibid., pp. 114-115.

For most projects the absolute rate of return[1] cannot be estimated.

. . . .

With the exception of independent projects it normally misranks even those for which it can be estimated.

. . . .

The ranking factor must therefore be some kind of relative return.[2]

. . . .

In view of the fact that there are numerous relative returns for the same project at the same point of time, it is necessary to identify the one that reflects the real urgency of the project to the business.

. . . .

Since these returns are relative to going on without the project for various periods of time, the basic problem is to identify the right period of assumed development.

. . . .

The worse the deferment with which a project is compared (the larger the losses that would be incurred in its absence), the higher the relative return, the better the alternative, the lower it is.

. . . .

What a project can make as against bad deferment alternatives is of no consequence so long as better ones are available. Its real urgency is determined by what it can make against its best alternatives.

. . . .

Since the best deferment alternative is the one relative to which the return from a project is the lowest, the lowest relative return obtainable is the measure of urgency.

. . . .

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[1]Terborgh defines the two kinds of returns on page 39 by saying:

> Basically, there are two different kinds of returns from a project, which we shall call "absolute" and "relative." The absolute return depends on the excess of the revenue generated by the project over the operating costs incurred by it. Since there is only one stream of revenue and one of costs, there is necessarily only one stream of difference between the two, hence only one absolute rate of return based on these differences. The relative return, on the other hand, depends on the difference between having the project and going without it for a specific period of time. Here there may be as many rates of return as there are possible periods of deferment.

[2]*Ibid.*, p. 39.

> it follows that the problem of investment analysis is to estimate minimum relative returns.
> . . . .
> These minimum relative returns are the ranking factors we are after.[1]

These minimum relative returns are arrived at by determining the minimum relative return for each project by using the MAPI formula. This formula, which uses five magnitudes, may be expressed as follows:[2]

$$\text{Rate of Return (without taxes)} = \frac{2+3-4}{1} \times 100 = \%$$

$$\text{Rate of Return (with tax)} = \frac{2+3-4-5}{1} \times 100 = \%$$

where:

1 = net investment,

2 = next year operating advantage,

3 = next year capital consumption avoided (loss in disposal value + next year's allocation of capital additions required),

4 = next year capital consumption incurred (depreciation of new item), and

5 = income tax adjustment.

The actual mechanics of the MAPI system consist of recording the data which leads to the finding of these five magnitudes on a prepared form. While MAPI recommends that each firm using this method develop a form that will meet its

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[1] *Ibid.*, p. 57. [2] *Ibid.*, p. 60.

particular needs, the form must:

1. Show the urgency rating of the project (the next-year after-tax return on net investment).

2. Show the next-year gain from the project, in dollars, as compared with going on without it for the year.

3. Show the next-year net gain, in dollars, after tax.

4. Show the next-year capital consumption.

5. Provide the data necessary to find the rate of return on equity capital.

6. Make it possible to compute the rate of return on the gross project investment.

7. Show how much of the net investment will be recovered to cash during the year as compared with going on without the project.[1]

The Machinery and Allied Products Institution believes that their method offers certain advantages over other methods of investment analysis. The advantages claimed for their system are:

1. It takes future deterioration and obsolescence into consideration.

2. It takes cognizance of revenue difference as well as cost difference.

3. It is applicable to a combination of replacement and expansion projects.

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[1] Ibid., p. 111.

4. It provides a usable measure of the cost of not replacing.[1]

The very factors that are considered to be advantageous by some people are often the same reasons why others dislike the system. So it is with the first of the advantages listed above. Joel Dean is not enthusiastic about this method because "it is hard to say that the method produces better guesses about the effect of future obsolescence than tinkering with the average-cost curve."[2] He seems to feel that the average minimum-cost rule could be misleading to those who are not wary because the formulas used to compute the charts are based on the stiff assumption that operating costs plus obsolescence inferiority increase through time along a straight line. In discussing reasons other than obsolescence which make the average minimum cost rule unrealistic, Dean says:

> Changes in demand, competitive relations, and price structure can restore value to a machine that by the minimum-cost rule has become ripe for replacement.[3]

However, these and many of the other unfavorable comments that have been made seem to hinge on the fact that the authors of the method are representatives of equipment manufacturers. In recognizing the limitations of their own method, MAPI made this comment:

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[1] MAPI Replacement Manual, p. 16.

[2] Olm and Richard, p. 15.

[3] Ibid., p. 16.

> Certainly you are better off with a rationally contrived guide to judgment, whatever its limits, than with the hocus-pocus that now passes for replacement analysis. With a good formula you will still miss the bull's eye in individual cases but you will develop over a period of time a better average score than by shooting blind. In the end it is your average that counts.[1]

In the preceding two chapters the aspects of the investment decision most commonly discussed in the literature have been described. The lack of current written material tends to make one wonder whether new methods may have sprung up, or if some methods may have been overlooked in the research process. In Chapter IV the results of a survey are presented from which an opinion can be derived about the existence of such a possibility.

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[1]*MAPI Replacement Manual*, p. 19.

CHAPTER IV

A SURVEY OF FOURTEEN CORPORATIONS

> The routine replacement fallacy maintains that scheduled periodic replacement of capital facilities is a practical and profitable substitute for an individual investment analysis of the economic desirability of individual replacement. For example, many fleet owners replace motor trucks on a routine basis (i.e., after a certain number of years or a certain number of miles) rather than by finding whether added net earnings from replacing an old truck with a new one will produce an adequate return on the added investment.[1]

One of the objectives of this paper is to determine the factors which influence businessmen in making their decision as to whether or not to repair or replace equipment items. The method that was chosen to accomplish this objective involved researching the literature for a tentative answer. The tentative answer was then to be verified by specific inquiries to selected corporations.

In the preceding chapter a listing of the factors and the elements has been given; however, it was seen that there are different opinions and mixed emotions about how they should be utilized. Fortunately these authors are not as divided in regard to what it is that should be determined from these criteria, as they are in regard to what the criteria should be. Most of the

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[1]Dean, "Measuring the Productivity of Capital," Harvard Business Review, January-February, 1954, p. 125.

writers are in agreement that it is the economical life of the item and the rate of return that can be achieved which they are interested in determining.

While the objective of the survey was to verify the data found in the primary literature, it was by no means the only objective. The purposes of the survey were to discover whether the factors of the repair-replacement decision making process (as discussed by the writers in the field) were actually used in American business; if there were factors being used in business which had not been described in the writings; what importance businessmen attached to each of these factors; which hierarchical level set the policy for equipment repair and replacement; and which hierarchical level actually made the repair-replacement decision.

In selecting the corporations to which these questions were to be sent, three general guidelines were developed. First, the firms that were to receive inquiries had to be ascertainable as owning or using a large number of operating type equipments (versus manufacturing equipments). Second, the businesses were to have extended and diverse operations. This was the most difficult of the guidelines with which to comply; all of the firms replying have diverse operations, but in two cases the size of the geographic area covered by their operations was that of a single large metropolitan area. Finally, the size of the organization was a determining factor. All firms to which inquiries were sent have property (equipment or operating assets)

valued (after consideration for depreciation) in excess of one million dollars.

A total of twenty-one corporations was selected and each was sent a questionnaire consisting of six questions. These questions and the replies received are given in the latter part of this chapter. The majority of the business entities chosen (Table 3) are engaged in renting, leasing, and/or providing consultant service for motor transport fleet operations. The prime reason for selecting firms involved in automotive fleet operations and/or leasing operations is that organizations so engaged are easily identifiable as meeting the guidelines set forth above. Another factor taken into consideration was that in many respects the problems encountered in managing a motor vehicle fleet are more nearly parallel to the military situation than other aspects of civilian business operations. But, though similar, it would be incorrect to concentrate on motor vehicles for this reason alone. Although the firms in this category are primarily engaged in motor vehicle operations, they also lease or manage aircraft, mining equipment, locomotives, barges, production machinery, and office equipment.

To enhance further the diversity of the survey, information was requested from four other general types of businesses. Two of these general categories are each represented by a single firm. One of these corporations owns, leases, and repairs (their own) railway cars of various types and models. The other owns and operates marine equipment, which is used to

TABLE 3

SIZE AND SCOPE OF SURVEY

Type of Business	No. of Inquiries Sent	Replies		Usable Replies		Average Net Value of Property (in millions)		Average No. of Operating Units Managed	
		No.	%	No.	%	Replying	Reported	Replying	Reported
Petroleum Industry	5	4	80%	5[a]	100%	$1,907	$1,907[b]		
Vehicle Fleet Management[c]	12	7	58%	5	42%	41.9	20.8[d]	30,742[e]	24,583[e]
Railway Car Leasing	2	1	50%	1	50%				
Marine Transportation Service	1	1	100%	1	100%	4.9	4.9	81	81
Office & Electronic Equipment	1	1	100%	0	0%				
Total	21	14	66%	12	57%				

[a]One firm returned two usable sets of answers: one for exploration and production operations and one for product marketing operations.

[b]One firm that has been deliberately included is considerably smaller than the others.

[c]Corporations in this category also lease or manage material handling equipment, busses, airplanes, helicopters, locomotives, barges, mining equipment, production machinery, and office equipment.

[d]Dollar amounts represent the net value of rented or leased equipment; organic property is excluded. Two firms that have been deliberately included are considerably smaller than the others.

[e]Motor vehicles only.

transport supplies and personnel to off-shore oil drilling rigs. This firm is presently operating in two oceans and is serving four different geographically disbursed major oil fields.

The inclusion of the third general type of business--that of office machines and electronic equipment--was stymied when information which had been anticipated could not be provided by the firm from which it had been solicited. The reason given for the refusal was that "company policy" prohibited the release of this information, since it was confidential.

The final general type of business from which information was requested was that of the petroleum industry. This category was selected because of the ease with which it qualified under the rules of selection; in addition, it was desired to ensure representation from firms with large formal hierarchies. The inclusion of such organizations was desired because the organizational structure of the Department of Defense is characterized more by its magnitude and formality than by anything else.

The response to the inquiries was gratifying: 50% or better in each general category and 66% overall. Of the fourteen responses that were received, all but three materially added to the findings of the survey. Of the three that did not contribute materially to the survey, one firm pertained to the vehicle fleet management group; one to the railway car leasing group; and one to the office machinery and electronic equipment group. It is felt that the lack of these three responses does not affect

the validity of this study, particularly in view of the total number of responses received.

All inquiries were addressed to the presidents of the corporations. The purpose of this was to increase the response and to see if, when the task of replying was delegated, any pattern of hierarchical level or functional area would develop. As was expected, such patterns did develop within the general business groupings. The exact trends are shown in Table 4.

TABLE 4

TITLE OF RESPONDER BY BUSINESS CATEGORY

Type of Business	Title	Quantity
Petroleum	Comptroller	2
	Assistant Comptroller	1
	Mgr., General Account Department	1
Vehicle Fleet Management[a]	President	1
	Secretary to the President	1
	Vice President[b]	4
	Unidentified	1
Railway Car Leasing	President	1
Office & Electronic Equipment	Federal Special Representative	1
Marine Transportation Service	Director of Research and Development	1
		14

[a]Corporations in this category also lease or manage material handling equipment, busses, airplanes, helicopters, locomotives, barges, mining equipment, production machinery, and office equipment.

[b]One Vice President was specifically identified as Vice President of Operations.

In the larger more complex petroleum firms the answers were provided by personnel bearing titles that would indicate they perform controllership functions. As will be seen in the answers to the survey's questions, these organizations know what is meant by financial management, and they are using it as a tool in maintaining control over capital expenditures.

The replies from the firms engaged in the operation of equipment, primarily for the service of others, were signed almost exclusively by top management officials. It can be assumed that these are line personnel directly involved in the operation of these assets. Within these organizations it can be hypothesized that the investment decisions are less routinized and more intuitively resolved than those in the petroleum industry. As always, however, there are exceptions; one of the larger fleet management firms maintains detailed records on 40,000 vehicles and has developed sets of specific standards for the replacement of equipments. In spite of the techniques used, management makes or reviews all decisions that are made.

An indication of the importance placed on the investment decision can be gained by grouping the replies by the title of the signer. Such a summary is given in Table 5. The title appearing most frequently in the responses was that of Vice President; there were four of these. The next most common titles were those of President and Comptroller, of which there were two each. Adding to these the responses signed by the Director of Research and Development gives a total of nine

TABLE 5

SUMMARY OF RESPONDERS BY TITLE

Title	Quantity
President	2
Vice President	4
Secretary to the President	1
Comptroller	2
Assistant Comptroller	2
Manager, General Accounting Department	1
Director of Research and Development	1
Federal Special Representative	1
Unidentified	1
Total	14

replies, or 64% that were signed by upper level (corporate) management. This is taken as a positive sign that replacement decisions are important and that they have a vital influence on the "economic life" of the company itself.

The actual questions asked and the replies received from the individual firms are given below, grouped by general business categories. The designations--Firm A, Firm B, etc.--that identify the individual replies do not identify specific corporations. Under each question these titles identify different firms. This has been done in order to respect the confidential nature of some, but not all of the replies. With the exception of Question 2, there are two tables immediately

following each question and the replies thereto. The first of these tables is a summary by type of business of the number of replies received, and the number of usable answers to the question. The second table is a summary of the actual replies to the question.

Question Number 1.--What criteria (factors) and/or policies are used by your firm in deciding whether to repair or replace items of equipment?

Petroleum Industry:

Firm A: Economical evaluation of dollars involved.
Alternative repair-replacement possibilities.
Safety standards.
Repair capability.
Availability of replacement items.
Legal considerations.

Firm B: Comparative cost of repairs vs. replacement.
Safety.
Lost time and loss of production for each method.
Operating cost of resulting system.
Availability of on-hand replacement equipment.
Adaptability to expansion.
Adaptability to automation.
Comparison of required useful life and useful life after repair or replacement.
All costs in present-worth dollars.
All costs in actual dollars.

Firm C: Capacity of repaired item to function and maintain competitive position vs. replacement with updated new item.
Anticipated required life of item.
Economic advantage of repair.
Depreciated value of item
Cost of replacement vs. repair.

Firm D: Rate of return (discounted-cash-flow).
Age.
Mileage.
Alternative possibilities.
Investment costs.
Operating costs (old and new).
Obsolescence.
Timing replacement to attain the lowest combined actual depreciation, operating, and maintenance costs.
Market value of trade-in.

Firm E: Original cost of the item to be repaired.
The amount of original cost which has been recovered.
Degree of obsolescence.
Cost of replacement unit.
Return expected from replacement unit.
Additional value or productive life repair cost will add to repaired equipment.

Vehicle Fleet Management:

Firm A: Length of service.
Total mileage.

Firm B: Obsolescence.

Firm C: Repairs are made on the probability of failure while vehicle is in possession of lessee.
Replacement accomplished on fixed mileage schedule.

Firm D: Obsolescence
Action that will result in total lower cost per productive unit.
Utility gained by the repair cost.

Railway Car Leasing:

Firm A: Past experience.
Statistical repair data.
Cost of repairs versus remaining revenue that can be earned.

Marine Transportation Service:

Firm A: Obsolescence.

TABLE 6

NUMBER OF USABLE REPLIES TO QUESTION NUMBER 1

Type of Business	Total Number of Replies	Replies to Question #1	%
Petroleum Industry[a]	4	5	125%
Vehicle Fleet Management[b]	7	5	71%
Railway Car Leasing	1	1	100%
Marine Transportation Service	1	1	100%
Office & Electronic Equipment	1	0	0%
Total	14	12	86%

[a]One firm returned two usable answers--one for exploration and production operations and one for product marketing operations.

[b]Corporations in this category also lease or manage material handling equipment, busses, airplanes, helicopters, locomotives, barges, mining equipment, production machinery, and office equipment.

TABLE 7

FACTORS AFFECTING INVESTMENT ANALYSIS AS REPORTED BY CORPORATIONS SURVEYED

Factor	Number of Firms Reporting
Obsolescence	7
Economic Evaluation of Dollars Involved	6
Alternative Possibilities	3
Availability of Replacement Items	3
Age	3
Mileage	2
Anticipated Required Life of Item	2
Safety	2
Statistical Repair Data	2
Investment Costs	2
Operating Costs	2
Utility Gained by Repair Cost	2
Lost Time and Loss of Production	1
Market Value of Trade-in	1
Cost of Original Item	1
Amount of Original Item that has been Recovered	1
Timing Replacements to Attain Lowest Combined Actual Depreciation, Operation, and Maintenance Costs	1
Cost of Repairs Versus Remaining Revenue that can be Earned by this Asset	1
Repair Capability	1
Adaptability to Expansion	1
Adaptability to Automation	1
Legal Requirements	1

Question Number 2.--What weight or importance, relative to the other factors, is given to each of these criteria?

Petroleum Industry:

Firm A: The weight attached to each factor varies with the situation; however, safety and loss of production rank very high.

Firm B:

Obsolescence.	50%
Required life of item	20%
Economic advantage of repair. . .	15%
Depreciation.	10%
Cost of replacement versus repair	5%

Firm C: Financial economics governs in making the investment decision except when other factors may be of sufficient importance to warrant special consideration.

Firm D: Repair-replacement decisions are normally made on the basis of the economic evaluations, but other factors may influence them.

Firm E: The capital budget process interrelates the factors listed in Question 1.

Vehicle Fleet Management:

Firm A: Whether or not to repair a vehicle depends on the length of its remaining economical life. It must be long enough for the vehicle to earn sufficient revenue to pay for the cost of repairs.

Firm B: The vehicles visit the ship only once a year; therefore, repair work is authorized and performed on the basis of the probability of future breakdown.

Other Firms: Obsolescence is the controlling factor.

Railway Car Leasing:

Firm A: The accomplishment of repair work is dependent upon whether or not the remaining period of economic life is long enough to pay out the repair cost.

Marine Transportation Service:

Firm A: Obsolescence is the controlling factor.

TABLE 8

NUMBER OF USABLE REPLIES TO QUESTION NUMBER 2

Type of Business	Total Number of Replies	Replies to Question #2	%
Petroleum Industry[a]	4	5	125%
Vehicle Fleet Management[b]	7	5	71%
Railway Car Leasing	1	1	100%
Marine Transportation Service	1	1	100%
Office & Electronic Equipment	1	0	0%
Total	14	12	86%

[a]See footnote a, Table 6, page 55.

[b]See footnote b, Table 6, page 55.

<u>Question Number 3</u>.--When considering whether or not to repair or replace an item, what functions or cost elements are included in the estimated cost to repair and the replacement costs of an item?

Petroleum Industry:

Firm A: Item F.O.B. supplier.
Freight.
Sales taxes.
Handling, unloading, drayage.
Preparation or changes to existing facilities.
Loss of use by change-over.

Firm B: Labor--company or contract.
Material and supplies.
Shop expense, where applicable.
Shutdown costs.
Applicable prorates.
Purchase price of similar item F.O.B. our local storehouse.

Firm C: Comparative costs of repairs versus replacement.
Lost time and loss of production for each method.
Operating cost of resulting system.

Vehicle Fleet Management:

Firm A: Maintenance Costs.
Depreciation.

Other Firms: The remainder of the firms in this category are the ones that had previously stressed the importance of obsolescence. In these firms the length of the economic life for equipments is decreed by a managerial judgment decision. The lengths of the economic life that have resulted from these decisions are such that most of the equipments are replaced prior to the time that they require excessive maintenance. Therefore, these firms do not concern themselves with any particular cost elements.

TABLE 9

NUMBER OF USABLE REPLIES TO QUESTION NUMBER 3

Type of Business	Total Number of Replies	Replies to Question #3	%
Petroleum Industry[a]	4	3	75%
Vehicle Fleet Management[b]	7	5	71%
Railway Car Leasing	1	0	0%
Marine Transportation Service	1	0	0%
Office & Electronic Equipment	1	0	0%
Total	14	8	57%

[a]See footnote a, Table 6, page 55.

[b]See footnote b, Table 6, page 55.

TABLE 10

COST ELEMENTS AFFECTING INVESTMENT ANALYSIS
AS REPORTED BY CORPORATIONS SURVEYED

Cost of Replacement Item F.O.B. Supplier
Freight
Sales Tax
Handling, Unloading, and Drayage Charges
Site Preparation or Changes to Existing Facilities
Loss of Use by Change-over
Labor--Company or Contract
Materials and Supplies
Shop Expense, Where Applicable
Maintenance Costs
Shut-down Costs
Applicable Prorates
Lost Time for Each Method
Loss of Production for Each Method
Operating Cost of Resulting System
Depreciation
Obsolescence

Question Number 4.--What hierarchical level of the organization determines the criteria and policies to be followed in repairing or replacing items of equipment?

Petroleum Industry:

Firm A: Policy is established at the higher levels of management.

Firm B: All company policy is determined at the Board of Directors-Officers level. Subsequently, the corporate engineering, purchasing, and comptroller departments, along with the managements of the operating companies and subsidiaries jointly establish criteria for making the repair-replacement decision.

Firm C and D: Policies are decided at the management level.

Vehicle Fleet Management:

Firm A: Policies are normally set by management, usually a Vice President (in charge of Fleet) or the Traffic Manager. However, it is more desirable to have the traffic manager of the fleet set the policy because he has a more intimate knowledge of the actual physical condition of the fleet.

Firm B: Replacement policy is established (based on obsolescence) at national headquarters. The regional managers establish the repair policy to be followed in their respective regions.

Firm C: Criteria are measured and policy recommended at the departmental level. A policy committee, consisting of senior Vice Presidents, rejects or accepts the recommended policy. If accepted, the policy is then embodied into the overall fleet management policy and procedures for the firm.

Railway Car Leasing:

Firm A: Annually the accounting department reviews the repair costs by car, by group, and by age. It then submits its comments on the preceding year's practices and suggests areas for change to top management. Management then approves or rejects the suggested changes.

TABLE 11

NUMBER OF USABLE REPLIES TO QUESTION NUMBER 4

Type of Business	Total Number of Replies	Replies to Question #4	%
Petroleum Industry[a]	4	4	100%
Vehicle Fleet Management[b]	7	3	41%
Railway Car Leasing	1	1	100%
Marine Transportation Service	1	0	0%
Office & Electronic Equipment	1	0	0%
Total	14	8	57%

[a]See footnote a, Table 6, page 55.

[b]See footnote b, Table 6, page 55.

TABLE 12

HIERARCHICAL LEVEL AT WHICH POLICY IS DETERMINED

Item	Number of Firms Reporting
Policy Set by Management	4
Policy Determined at the Board of Directors-Officer Level	1
Replacement Policy Set by National Headquarters; Repair Policy Set by Regional Managers	1
Policy Recommended by Departments, Approved by Management	1
Policy Recommended by Departments, Approved by Policy Committee (Senior Vice Presidents)	1
Total	8

Question Number 5.--Which hierarchical level is authorized to make the decision as to whether or not to repair or replace an item of equipment?

Petroleum Industry:

Firm A: The authority to make this decision depends upon established policy and the dollar amounts involved. It ranges from the Chairman of the Board to field supervisors.

Firm B: The decision to repair or replace a particular equipment item can be made at a number of levels subject to specific dollar limitations. The lowest level authorized to make this decision is a field superintendant.

Firm C: The answer to this question depends upon the costs involved. Small jobs can be decided by a foreman or superintendant.

Firm D: It will vary with the project and equipment under review. Within policy and authorities for expenditure field executives may make the decision.

Firm E: Within the limits of a well established policy, a decision to repair equipment is frequently made by individuals at a relatively low level in the organizational structure.

Vehicle Fleet Managent:

Firm A: The service manager makes the repair decisions. When he has doubts about the desirability of making a repair, he refers the decision to a higher organizational level.

Firm B: Management makes the decision using "needs" as the criteria, rather than a pre-set policy.

Firm C: Within the framework of a national purchasing program, regional managers retain complete control in regard to repair or replacement of individual vehicles.

Railway Car Leasing:

Firm A: The Mechanical Division has full authority to make decisions on individual repairs. They are aided by the Financial Division, which furnishes cost data; and the Sales Department, which furnishes demand, rental, and term data. Large programs are approved by the Board of Directors.

TABLE 13

NUMBER OF USABLE REPLIES TO QUESTION NUMBER 5

Type of Business	Total Number of Replies	Replies to Question #5	%
Petroleum Industry[a]	4	5	125%
Vehicle Fleet Management[b]	7	3	43%
Railway Car Leasing	1	1	100%
Marine Transportation Service	1	0	0%
Office & Electronic Equipment	1	0	0%
Total	14	9	64%

[a]See footnote a, Table 6, page 55.

[b]See footnote b, Table 6, page 55.

TABLE 14

HIERARCHICAL LEVEL AT WHICH THE REPAIR-REPLACEMENT DECISION IS MADE

Decision Making Level	Number of Firms Reporting
Operating Level	3
Operating Level or Management Level (depending upon policy and/or dollars)	5
Management Level	1
Total	9

<u>Question Number 6</u>.--Are statistical models used in making the decision to repair or replace items of equipment?

Petroleum Industry:

Firm A: Statistical models are not normally used when making decisions as to the repair or replacement of equipment items.

Firm B: Various statistical models are used in making repair-replacement decisions. For low priced-high incident of replacement items, simple statistical models based on experience are used, while rate of return and pay-out evaluations are used on the higher priced-low frequency replacement items.

Firm C: Experience factors are utilized in making the decision to repair or replace items of equipment.

Firm D: The time value criterion, sometimes called "discounted cash flow rate of return" is employed.

Firm E: When necessary and practical, justification studies are made to guide the decision making process.

Vehicle Fleet Management:

Firm A: Statistical models are used in the development of criteria employed in the decision making process and in programming for Data Processing.

Firm, B: Of course, but statistics, averages, and all other such material should be weighed in the face of local facts.

Railway Car Leasing:

Firm A: On marginal cars a formula, which takes into account the various economic factors is applied before a decision is made. This formula may be stated as follows:

$$I = R \times E - O - C$$

Where: R is the rental rate for the item,
E is its remaining useful life,
O is the operating cost for the remainder of the item's useful life,
C is the estimated cost to repair, and
I is the net income the car will produce during its useful life.

After I has been determined a judgment is made as to its adequacy. If found sufficient, the car is repaired; otherwise, it is replaced.

Marine Transportation Service:

Firm A: Statistical models are not used.

TABLE 15

NUMBER OF USABLE REPLIES TO QUESTION NUMBER 6

Type of Business	Total Number of Replies	Replies to Question #6	%
Petroleum Industry[a]	4	5	125%
Vehicle Fleet Management[b]	7	2	30%
Railway Car Leasing	1	1	100%
Marine Transportation Service	1	1	100%
Office & Electronic Equipment	1	0	0%
Total	14	9	64%

[a]See footnote a, Table 6, page 55.

[b]See footnote b, Table 6, page 55.

TABLE 16

UTILIZATION OF STATISTICAL MODELS

Type of Model[a]	Number of Firms Reporting
Economic Evaluation of Dollars[b]	3
Experience Factors[b]	2
Justification Studies	1
Mathematical Models and Statistical Averages	2
No Models Used	2
Total	10

[a]The term "statistical model" was purposely not defined in the basic question. The captions that appear here reflect how the term was interpreted by the respondents.

[b]One firm reported that the method used varied, depending upon the dollar amounts involved. This accounts for having one more method reported than there were replies.

General Comments

Several of the responding firms, in addition to answering the specific questions, contributed information that explains further how they make the repair-replacement decision. These additional comments are given below.

Firm A: Replacement, generally speaking, is considered a capital budget decision, and as such, is guided by conventional project evaluation. When the capital budget is developed each year, prospective projects are evaluated by local management and successively screened and accumulated into regional

programs, divisional programs, and corporate programs. The world-wide capital budget, including motor vehicle projects, as divisional line items, is finally subject to approval by the Board of Directors.

Firm B: Being a relatively young company with new or nearly new equipment, the problem of replacement is not a pressing one at this time.

Firm C: The Office Machine Division, which was recently started, does not have the experience in physical age to allow us to determine replacement policies.

Firm D: Because of the many factors that enter into the analysis of a particular replacement problem, it is rather difficult to answer "these questions" by correspondence. Experience shows that the answers will vary depending upon the area (geographical) of operation, type of customer, equipment, and chauffeur.

Firm E: The decision is not whether to retire or replace, but rather when to retire. The Mechanical Department must approve the repair of each estimate before any car can be repaired.

Firm F: This firm does not presume to advise and counsel on trucks, since "they are a complex breed of cats." A contribution that is made in the field of auto fleet management is the recommendation of a sound economical replacement policy. This plan envisions replacement at a time when you have gotten your money's worth of usage out of the old item and it still has

enough useful life left in it to command a good resale price. "After all, a good part of fleet management is merely common sense. You repair a car when it is the logical thing to do; and you replace a car when that is the logical thing to do."

Firm G: The interpretation of the many technical factors that must be considered in establishing economic repair limits and replacement criteria will vary according to:

1. What type of equipment is under discussion?

2. Was this equipment properly specified to do the work it is doing?

3. If not, is it over- or under-specified and in what regard (engine, body, clutch, tires, etc.)?

4. Again, if not, was it properly specified at first and then subsequently used on other work; and if this is so, at what chronological point was it diverted?

5. Has the equipment been properly maintained? If not, in what regard has maintenance fallen short? This factor by itself could be the reason for the decision to repair or replace, regardless of other factors.

6. How old is it, how many miles or hours does it run, and what are the roads and terrain features of the area in which it operates? Does it run regularly or spasmodically, once scheduled, or on an as-needed or stand-by basis?

7. Is the driver or operator fully qualified for his job? Has his training been on-the-job or more formal, and if the latter, to what extent? What is the amount and quality of his supervision?

8. Is the equipment driven or operated by one or two men regularly, or is it being handled by many different men?

CHAPTER V

CONCLUSIONS

> Our national survival depends on our ability to come up with good answers as consistently as possible. Therefore, we must make defense planning . . . an intellectual rather than an emotional process. To do so we must turn our attention to the question of what's right, not who's right.[1]

In studying the manner and method by which American businessmen decide "what's right" rather than "who's right," certain underlying concepts or assumptions have been ascertained. Because these concepts seem to form the framework and boundaries which govern the capital expenditure decision making process, the ten suppositions that have been identified are hereafter referred to as the Laws of Investment Analysis. In view of the limited scope of this paper it is realized that there may be other laws than those that are cited in this study. However, it is felt that any such additional laws will result more from semantics than from further revelations.

In setting forth these concepts, their presentation has been ordered in a sequence that reflects the importance, from a military point of view, that has been attached to each of them.

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[1] Enthoven, p. 158.

Laws of Investment Analysis

Law #1. The totality of factors must be considered in making the investment (repair-replacement) decision.

As was seen throughout the study each investment decision was affected by a multitude of diverse and varying factors. While it is desirable to reduce all of these factors to quantitative terms and to interrelate them by mathematical means, it is not always possible to do so. It is essential, therefore, that the factors which cannot be quantified or which cannot be interrelated by mathematics are not ignored in the decision making process.

Law #2. The length of an equipment's life should be determined by its own economic life.

An item should be retained and used only so long as the stream of services that it provides is the most economical way of procuring these services. In determining the cost of alternative ways to produce the same services the capital consumption costs, the cost required to remove and dispose of the old process, and the salvage value of the old equipment must be considered. This is necessary to ensure that an item will not be replaced prior to the end of its economic life, even though there may have been technological improvements prior to this point in time. From management's viewpoint it is not the cause--i.e., the wearing out of the equipment, the advent of a better machine, or the disappearance of the need for the service --that is important. What is important is the discovery of the

point in time when the present machinery no longer provides the most efficient and effective way of achieving the given objective with an acceptable degree of assurance.

<u>Law #3. It is the relative, rather than the absolute, difference between projects or courses of action that is important</u>.

It is not the total dollars spent nor the total dollars that will be earned (or saved) that is material. It is the amount that could be earned (or saved) for every dollar that is spent, as compared with what could be earned if some other expenditure was made, or if no expenditure was made.

<u>Law #4. All capital expenditure projects should compete equally for the funds that are available for this purpose</u>.

The identification of the desirability and the attention that should be given to a specific repair-replacement problem by category classification is a step toward mediocrity. Such methods avoid the true objective (the determination of the most economical matrix of resources) of investment analysis. While the classifications of safety, personal comfort, etc., do not seem to lend themselves to competing with other investments, such a thought is not true. What has really happened is that these projects have competed against the group and have triumphed without having to be examined comparatively. Because the evaluation of the services that will be received as a result of such decisions has been made implicitly, management most frequently does not know the relative cost of its actions.

If, on the other hand, a truly competitive analysis had been made, the relative cost of these "mandatory" investments might have led to a complete reappraisal of the work that required them. Such reappraisals often result in revision, modification, or termination of the basic work.

Law #5. The analytical techniques used in investment analysis must be readily understandable and must result in a more economical use of management's time if it is to be accepted.

Management's use of techniques and formulas is directly proportional to its confidence in the results they produce and the time required to use them. Both of these components, particularly the confidence of management, are affected by the user's knowledge and understanding of the logic and assumptions that are behind the techniques. The technological level of our society and the complexities of the business environment, which have made the modern manager a "jack-of-all-trades and master of none," impedes the adoption of complicated or sophisticated systems. To be beneficial an analytical technique must be relatively simple and easily understood.

Law #6. Maintenance costs increase with the age of the investment.

Behind this generalization, which is true, lie some of the most difficult problems encountered in investment analysis. What is the time shape of an equipment's maintenance costs? How

can it best be determined? The most frequently used methods seem to be the manufacturer's recommendations, engineering studies, and studies of empirical data. While all have been used successfully in selected environments, none have been proven sufficiently versatile for general application.

Law #7. The efficiency of an item of equipment decreases with the age of the item.

This principle, which results from the same causes that produced the previous law, is not the inverse of Law #6. At best there is but a causal relationship between increased maintenance and decreased efficiency. The importance of these two laws is the recognition they give of certain basic principles of physics.

Law #8. Projections into the future are not accurate and require offsetting compensations and periodic re-evaluations, or both.

It does not take an astute observer to come to this conclusion; however, its importance to the investment decision cannot be over-emphasized. Relatively small changes in the magnitude of the variables, which involve projections into the future, can make significant changes in the desirability of the different alternatives. The project evaluation system should provide for an automatic re-evaluation of the situation and the deviations from the original projections.

<u>Law #9. The preparation and maintenance of property, costs, and operating records for equipment items is desirable, but is often considered too costly or not feasible</u>.

Because good decisions require knowledge, one of the real skills needed by management is the ability to determine which information is worth the cost of collecting it. Frequently, due to the length of time between requirements to make similar investment decisions and the uncertainty with which the recorded information is used, managers often feel that there is no need for records of this type. Fortunately the majority of today's decision makers have more foresight than this. Nevertheless, maximum benefits must be achieved from the records that are maintained if they are to pay for the cost of keeping them.

<u>Law #10. Future earnings and costs, to be comparable, must be converted to equivalent values</u>.

In the business community it is generally accepted that the expenditure of a dollar in future years is less costly than the spending of a dollar today. This is merely the recognition of the fact that present money, if properly handled, can earn a rate of return or interest. In investment analysis, because the cost elements for the different alternatives extend unevenly over a period of years, it is necessary to equate all costs to a common value if the comparisons are to be valid.

The Laws of Investment Analysis, as stated above, are as applicable to the armed forces of the United States as they are

to American business. Although the goal of the business world is different (maximizing profits) from that of the military (minimizing cost), the achievement of either is enhanced by following a plan of action that provides the most economical proration of capital expenditure dollars. Any system for analyzing capital investments that has as its purpose the maximization of resources will have to comply with these general concepts if it is to be effective.

The factors that were mentioned by the writers (see page 21) and those that are being used by the surveyed corporations (see page 56) are not as applicable to direct use by the Marine Corps as are the Laws of Investment Analysis. However, by making four modifications and four deletions, the factors cited by the writers make an excellent basic list for military use. The modifications that are required are:

From	To
General Business Outlook	General World Outlook
Future Markets	Areas of Possible Deployment
Future Products	Nature of Future Wars
Action of Competitors	Action of Enemies

The items to be deleted pertain to the profit factors and are:

Future Cash Earnings,

Time Shape of Future Cash Earnings,

Net Savings, and

Taxes.

Because the factors listed by the surveyed corporations support the allegation that there is a considerable amount of intuition being used in the analysis of capital investment projects, these factors are less useful from a military standpoint. However, in this group there are three factors that stand out and should, perhaps, be added to the master list. They are:

Safety,
Legal Requirements, and
Repair Capabilities.

The listing of Safety as a factor to be considered in the decision making process should not be construed as negating the law that all projects should compete equally for the funds available. Safety is a difficult factor to quantify and its influence on capital expenditures usually is resolved by a judgment decision. As stated earlier, this does not remove the need to determine the relative cost of having made this judgment.

The other two factors have been included in order to emphasize the importance of the existence of minimum requirements and the potential expense of failing to operate overhaul and rebuild facilities at capacity. There are certain fixed costs that must be incurred in operating repair plants regardless of the volume of work accomplished. To fail to utilize the repair capability to its maximum is to misuse a valuable resource.

The cost elements that were cited by the writers pertain more to manufacturing-type operations than to service-type

operations. Although all are applicable to the Marine Corps, a further detailed study of military operations would be required to determine upon which costs the emphasis should be placed.

Needless to say, the quantifiable elements relating to revenues are not applicable to the Marine Corps.

The adaptability to use by the military of the more commonly used commercial investment techniques or formulas is practically non-existent. This is because all of these methods are concerned with developing comparative rates of return or require the use of minimum attractive rates of return. Only the MAPI method goes beyond the ranking of projects and attempts to determine the proper timing for replacement action. However, the charts used in the MAPI technique, as presently developed, provide implicitly for such factors as capital consumption and use of specific tax depreciation methods. This renders their use by the military impractical.

Still, except for the undesirable intuitive and strict pay-off methods, this technique is the only one that has any possibility for conversion to Marine Corps use. By reconstructing the depreciation curves to show the anticipated or actual known depreciation rate of military items, usable charts could be developed. The major drawback to this would be the requirement to create different charts for each type of equipment and for each of the different operational conditions under which such equipments might be used. Another difficulty that must be weighed is that any such capital consumption curves

that are developed will contain an unknown degree of inaccuracy, due to man's inability to predict future events. In spite of the margin of error that would be inherent in such a system, it would, in all probability, give more satisfactory results than the present economic repair limit--a limit that declares an item of general equipment is uneconomical to repair when its repair or rebuild cost exceeds 65% of its acquisition cost.

In the large, complex, diverse, but formally structured military organization, the development and operation of an effective system for ensuring that the correct alternative (repair versus replacement) is chosen requires continuous and intensive support and direction by top management. In today's modern technological world the capital expenditures made today will dictate the organizational posture that can be achieved tomorrow--truly a responsibility that deserves upper hierarchical attention.

Before discussing the development and constituents of such a decision making system, it should be pointed out, as was stated in the Introduction, that the Marine Corps does have a usable procedure for solving this problem. However, inasmuch as this paper is not a study of that system, the comments that follow are made without specific regard to it.

The first task that must be undertaken in establishing this decision making process is to define the scope and objectives of the system. This is no mean task in itself. Is the objective the ensuring of the most economical use of the

equipment? Is it to ensure the fullest utilization of the Corps' maintenance capabilities? If so, which are the most important--those of operating units or the depot facilities? Is it to provide the most effective combination of new and repaired items within available resources?

It is suggested that unless this last-mentioned item is the true objective, the establishment of the system will not be worth the effort. Whatever objectives are chosen, they must be clearly defined and thoroughly explained.

Following closely on the heels of this task is the necessity of formulating policy. The current Marine Corps directives and publications are quite adequate in this respect. They set forth the necessary guidelines under which the maintenance program will be performed.

Within the framework of the procedure set forth by the defined objectives and the published policies, management must now identify the factors and cost elements that are to be considered in the making of the actual decisions. The factors cited by the writers of the literature on investment analysis, as modified earlier in this Chapter, are offered as a starting point for creating an all-inclusive Marine Corps list. Additional research would have to be conducted to determine the actual cost elements that should be considered.

A final step that must be performed by upper management is the development of the actual technique or formula that is to be used in making the individual repair or replacement decision.

It is envisioned that the technique will have to be sufficiently flexible to allow for the automatic changing of the consideration given to the different factors as a result of variations in them. For example, as the availability of maintenance dollars versus new procurement dollars changes, the technique should yield different answers when applied, all other factors and cost elements remaining the same.

The organization structure that is evolved to perform these functions can take many forms. The one that is actually adopted must provide for the coordination of the responsibilities that have been mentioned, namely: the determination of the scope of the system, setting the objectives, promulgating policy, identifying the influencing factors and cost elements, and the development of the formula or technique for the specific decision making situation.

The operating elements of the organization will now, in accordance with the directions provided by established policy, quantify the factors and cost elements to be used and will make the actual decision to repair or replace. It is necessary that the system give the operating manager, who is to make the decision, the data that he cannot collect from within his own organization. As nearly as possible, this type of information should be provided implicitly by the formula adopted.

The task of quantifying the factors and cost elements is basically the accumulation of data and the maintenance of records.

This task should be performed at the lowest possible level in the hierarchy. This does not mean that the data so generated will be retained at this level. Periodically such data must be accumulated and forwarded to the upper management coordinator for individual analysis and for use in the re-evaluation of the entire decision making process. Top management must perform these audits to ensure the continued validity of the system.

Because of the consequence of equipment breakdown and the lead time involved in procuring replacement items, the repair-replacement decision must be anticipated and often must be made in advance. This means some form of pre-planning is necessary. In the Marine Corps the budget is used for this purpose. Unfortunately, the investment expenditures are intermingled with all other costs that are anticipated by the budgeting unit. It is impossible, from the budget documents submitted, to determine whether adequate thought and consideration have been given to the investment decisions that may arise during the budget period. Further, these budgets cannot be used to determine the number of items that would be available for complete rebuild at the depot repair facilities, nor do they provide any indication of the number of new items that should be requested in the Marine Corps procurement appropriations.

The present Marine Corps method for ensuring financial support for the repair-replacement problem is considered inadequate. It is believed that the development and use of a

separate maintenance and capital budget is mandatory. By having the maintenance and investment dollars together in a single budget and appropriation, the interchangeability of dollars to support the proper decision will eliminate the hoarding and hiding of valuable resources because it is feared that equipments will have to be maintained beyond their economical life. In addition, any insufficiency of funds and the cause therefor will be more apparent and explainable under such a system.

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